moved, but the pool was only partially drained. The water has not been entirely withdrawn or the pool thoroughly cleaned since 1929. Apparently the most likely source of introduction of *Craspedacusta* to the pool was in the summer of 1936, when Mr. Harpham, Jr., emptied into it about a quart of water containing a large number of anuran amphibian eggs. This material was obtained from a nearby pond.

DAYTON STONER

NEW YORK STATE MUSEUM,
ALBANY, N. Y.

POST-GLACIAL CONSEQUENT STREAMS IN MAINE

IN August, 1936, the writer came upon a gorge on the Merriland River one and three-quarter miles from tide-water, cut about twenty feet through slate. If the till and gravel overlying the slate are added, the cut must be at least thirty feet deep.

The mouth of the Merriland River is located in the northern part of the Town of Wells, near Elms, in southern Maine. The river is nine miles long and from its source runs in an easterly direction for five and one half miles, controlled entirely by the Newington Moraine, then, where the Newington Moraine is very low, bends in a southeasterly direction to the sea. It is a very small stream, and during the summer months the flow is reduced to almost nothing. Only during the seasons of melting snows or heavy rainfall can the stream be dignified by the name of "river."

On the Kennebunk topographic sheet of the U. S. Geological Survey there are eight major streams that reach the sea. Two of these, the Mousam and Kennebunk Rivers, are larger than the other six and may be somewhat older. The writer observed that the Merriland River rises close to the two-hundred-foot contour, with about a mile of headward cutting beyond this. It was then noted that thirty-four streams and branches of streams on the Kennebunk sheet rise close to the two-hundred-foot contour, with evident headward cutting in some cases. Now the upper marine limit for this part of the coast is also considered to lie close to this contour. The writer considers these streams to be *consequent* streams developed during the uplift of the land after the last ice-sheet and ocean withdrew from this region.

When the ice withdrew, the land must have risen faster than sea-level, because the sea-level was also rising, due to deglaciation. When the water stood at the upper marine limit the last ice was withdrawing and the sea washed against the ice-front, as proved by Keith and Katz and others. Antevs says: "If, as is probable, the ocean at the uncovering of the Maine coast (about 30,000 years ago) was lowered some two hundred feet, the land was lowered some two hundred feet plus the amount of the height of the marine limit above the present sea-level. Places with the marine limit at two hundred and fifty feet altitude, for instance, were lowered four hundred and fifty feet and have later risen this amount."[1] It must have taken a long time for the land and ocean to attain their present relations. The consequent streams started their careers as soon as the strand line began to move downward, those streams near the upper marine limit starting first and other streams nearer the sea starting later. The cutting of the gorge of the Merriland River did not begin until late, as it is only about one hundred feet above the tide to-day at the upper part of the gorge.

Considering the fact that cutting goes on mainly during the springs of each year and in times of heavy rainfall, 30,000 years does not seem too long a time to accomplish the results observed. It is enough to say that the time since the upper marine limit, development of consequent streams and the cutting of the gorge of the Merriland River is a very long time, and may be greater than 30,000 years.

The writer believes that such consequent streams may be used to check approximately the upper marine limit, and as a means of testing the determinations of the upper marine limit already made. The word "approximate" is used because headward cutting varies on each of the streams so they can not be used as definitely as beaches, for instance, in such determinations.

It is also possible that where the field evidence of the upper marine limit and the sources of the consequent streams do not coincide, these consequent streams might be used to determine the differential coastal movements that have taken place since the Pleistocene period.

ROBERT W. SAYLES

HARVARD UNIVERSITY

[1] *Am. Jour. of Science*, 15: 328, April, 1928.

REPORTS

PILOT FITNESS AND AIRPLANE CRASHES[1]

IN the early days of aviation, particularly during the world war, the need for testing the fitness of pilots for flying was duly recognized. In later years, however, the importance of testing pilot fitness was overshadowed by the development of instruments and the stress laid on them as a guide for flying. In this a

[1] From the Research Laboratory of Physiological Optics, Baltimore, Md.

grave mistake may have been made. Recently there seems to be a growing conviction that the pilot is an important factor in the increasing number of airplane crashes.[2] There is perhaps a good reason for this conviction. It may be that with the rapid improvement in the facilities for aviation, the attitude of the pilot has changed with respect to the importance of his own qualifications, fitness and training and to the highly specialized nature of the services he was formerly called on to contribute and still has to contribute in emergencies. It may be also that not enough attention is paid to fitness in the selection of pilots and to making sure that they are in fit condition for service at all times when they are called on to render service. It seems strange that the plane should be carefully tested on every point of its construction and operation before each flight and little or no attention given to the pilot at that important time other than to see that he is on hand to fly. With the advance in scientific and mechanized control, the importance of the human factor has without question been thrust into the background.

During the world war we devised an instrument for testing the fitness of aviators. This instrument was used at Mineola for testing and studying the fitness of entrance candidates and later was taken to France by Dr. William Holland Wilmer, surgeon in charge of the Medical Research Laboratories, Air Service, A. E. F., for the purpose of studying the fitness of aviators already in the service for the various tasks required of them, particularly in combat flying. Since the war the instrument has been greatly improved and is now being manufactured by the Gaertner Scientific Corporation. As manufactured by this company the instrument has been still further improved. One of the earlier improved models was described in the *Archives of Ophthalmology*.[3] In 1933–36 this model of this instrument was used by Lieutenant-Commander C. J. Robertson, of the United States Naval Service, for the study of fitness for aviation on such points as entrance requirements, disqualification for the service on account of age, fatigue in relation to number of hours in the air, individual susceptibility to fatigue, etc. Dr. Robertson has published his results in a series of articles in the *U. S. Naval Medical Bulletin* and the *Archives of Ophthalmology*.[4]

With this instrument can be measured among other things the speed of change of adjustment of the eyes for clear seeing at near to clear seeing at far and back again to near. This involves a measurement of the speed of vision, the speed of use of the muscles of the eyes in the perfect coordination needed for the clear seeing of a small detail and the speed of accommodation. It constitutes an extremely sensitive test of the ocular and oculomotor fitness of the aviator and of small disturbances in this fitness; also a very delicate and effective test for bodily and mental fatigue and other disturbances in physical and mental facility and proficiency. Fatigue, for example, has to be tested through its effect on some function. Perhaps no more delicate means can be found for detecting fatigue than through its effect on speed in those uses of the eyes which require highly coordinated changes in muscular adjustment. The delicacy and accuracy of coordination that are required in these adjustments will be realized when one remembers that changes in the convergence of the eyes are made by six pairs of muscles which serve to support as well as to move the eyes, and that the breadth of the images on the two retinas which must be combined into one in seeing is, for the standard test object, of the order of thousandths of a millimeter. Also in changing the vision from near to far and back again to near, the muscles of accommodation must act in perfect coordination with the muscles that move the eyes. Still further, the sensorium must function at a high level of efficiency.

The test is without doubt one of the most sensitive that has ever been devised for the detection of any imperfection in the oculomotor, accommodative or sensory functions or any temporal disturbance in these functions. It is with these temporal disturbances that we are particularly concerned in this paper. Common causes of these disturbances are fatigue, loss of sleep, worry and all mental states which distract attention, the variations in physical and mental efficiency and alertness common to every one in the course of time, illness, etc. Any of these may be sufficient to cause the aviator to fail or falter at a critical time in the high degree of service that is required of him. The profound effect of fatigue and other disturbances of bodily and mental efficiency on such highly organized and delicate muscular coordinations as are required in

[2] Major-General James E. Fechet (Ret.), formerly chief of the U. S. Air Corps, for example, who has devoted a great deal of time to the study of airplane crashes, states (*Flight Surgeon Topics*, School of Aviation Medicine, Randolph Field, Texas, 1937, Vol. 1, No. 2, p. 44) that in more than half the number of cases these crashes are due to personnel error or to undetermined causes. In the personnel group he includes the following: the pilot, the weather man, the airline operations manager and the mechanic. Of these the pilot is of course a very important factor. A small per cent. of these crashes—less than five, he says—is due to mechanical failure—engine malfunctions, breakage of some part of the plane or its essential accessories. A considerably higher per cent. is due to bad weather—ice, fog or storm.

[3] C. E. Ferree and G. Rand, *Arch. Ophth.*, 15: 1072–1087, 1936.

[4] C. J. Robertson, *U. S. Naval Medical Bulletin*, 32: 275–283, 1934; *ibid.*, 33: 187–205, 1935; *Arch. Ophth.*, 14: 82–89, 1935; *ibid.*, 15: 423–434, 1936; *ibid.*, 17: 859–876, 1937.

the speedy use of the eyes is too well recognized to need further mention here.

It seems strange, indeed, that so much care is taken to see that the plane is in perfect condition before a flight is undertaken and so little attention given to the condition of the aviator. While it is true that a human being can not be treated as a machine, we do know, as noted above, that he is subject to many disturbances from day to day that render him unfit for those services which require a supernormal fitness and proficiency and involve a responsibility for human life and safety. It seems only reasonable, therefore, that the fitness of the aviator should be tested before each flight is undertaken as well as the fitness of the plane which he operates. It is surely not enough to require only an entrance test of fitness and then allow him to go on without further check, even without regulation of his conditions of living, until age or some mishap retires him from service.[5]

Our personal feeling is that a test should be made of each aviator immediately before and after each flight. We have the following reasons to offer for this:

(1) The test before the flight should be used to prevent the aviator from going into the air when he is clearly and dangerously unfit for service. It is neither fair nor good public policy that a knowledge of his fitness should depend upon his own report. In combat flying in particular he might well be prevented from making such a report through fear of being called a slacker or because of patriotism or personal pride. In commercial service, too, many reasons might operate to deter him from making a report of unfitness. The responsibility for making such report should be taken out of his hands and consigned to a competent examiner. A surgeon, however long his experience and however well demonstrated his ability, voluntarily subjects himself to a test of steadiness of hand and keenness of eye before undertaking a critical operation. Surely in these offices requiring services equally responsible for life and safety, there should be some test of fitness immediately before the service is undertaken. Such precautions might be considered extreme had it not been so clearly demonstrated that something is radically wrong in modern aviation.

(2) The test at the end of the flight would indicate how well the aviator has stood the strain of his service. It would give valuable information as to his susceptibility to fatigue and make it possible to assign him to the length and kind of service he is capable of performing. It would also give a great deal of valuable general information as to the number of hours in the air and the amount of strain which aviators, taken collectively, can reasonably be expected to stand.

(3) From the results of the tests, graphs or curves can be plotted which will give a splendid picture of the aviator's fitness, his endurance, his susceptibility to fatigue, the consistency of his service, etc. In short, these records would serve as the basis for a high type of personnel service in aviation. From these graphs it can also be readily seen when the aviator is becoming incapacitated for service through age or some other cause. This alone should be a sufficient reason for adopting some such program.

(4) A feasible test and instrument are available. The test does not require more than ten minutes to perform and the result can readily be given a numerical rating. The instrument is easy and convenient to operate and the entire program well within the technical capabilities of the average flight surgeon.

Two forms of the test may be suggested: (1) The time required for the discrimination of the object at near, the change to far and back again to near may be measured in each test; or (2) in a series of preliminary tests the median or average times required for these performances may be determined for each aviator and these be taken as his standard of performance. In the routine procedure of testing, the instrument should be set to give these times of exposure. The test may consist of ten or some suitable number of trials to ascertain in what percentage of cases the aviator can attain his standard of performance. This percentage may be accepted as the index of his fitness at that time.

The instrument recommended may be called a multiple-exposure tachistoscope. As described in the *Archives of Ophthalmology*,[3] it comprises a driving mechanism, four sectored disks so arranged and of such sizes as to expose in immediate succession, in turning, a near test object on the left, a far test object in the median plane and a near test object on the right. The test objects are the letter E, the openings of which can be turned in eight different directions to give an objective check on the judgment. The far test object is provided with a remote control such that these adjustments can be made by pressing an electric key at the position of the examiner. The distance of the far test surface and the lateral separation of the

[5] We understand that some improvement in this respect has already been made or is in contemplation. The following, for example, is quoted from the article by Major-General Fechet referred to earlier in the paper: "Striving to promote continued pilot fitness, we developed a new profession in the Army—that of Flight Surgeon. He has paid us handsome dividends. We found that annual or semi-annual examinations were not enough. We needed a smart medico to keep the pilots under daily observation. . . . Flight Surgeons paid off in reducing airplane crashes. I commend that thought to commercial airline operators." He says further: "Health is mental as well as physical. I think the mental side plays a bigger rôle in air pilot health than the physical. A man who is worried and preoccupied about domestic discord or financial extremities may be more unsafe than one subject to fits or fainting spells."

two near test surfaces can be varied at will. The sectored disks are turned by means of a constant-speed motor provided with gears to give suitable reductions in speed, and an intermittent gear which causes the disk covering the test objects prior to the beginning of the exposure to stop in exactly the same position at the end of a single rotation. In the preferred form the values of open sector are adjusted by small worm-gears which serve both to change the position of the movable disks and to hold them firmly in position for any given setting. Exposure may be made in continuous series up to four seconds. Both the angular values of open sector and the times of exposure can be read from suitably positioned, graduated scales.

A later form of the instrument is an electrical tachistoscope. This is the form now being made by the Gaertner Scientific Corporation. In Fig. 1 are

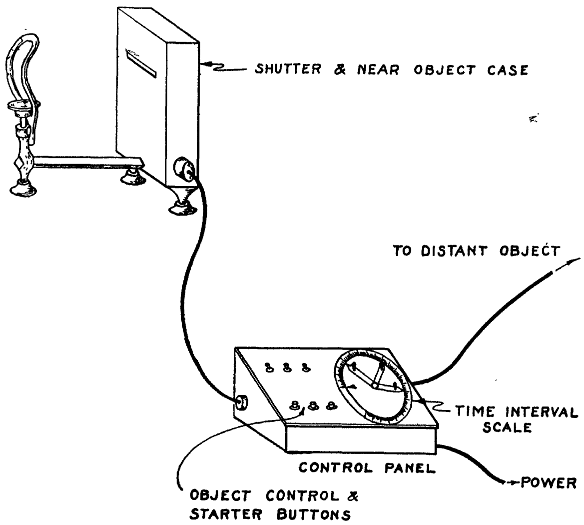

FIG. 1. An electrical, multiple-exposure tachistoscope.

shown the control panel and the case containing the near objects, the means for illuminating these test objects and the shutters for exposing both the near and the far test objects. The shutters are operated electromagnetically and are so arranged as to expose in sequence the test objects in the order noted above, namely, the near test object on the left, the far test object in the median plane and the near test object on the right. In the control panel are housed relay devices for operating the shutters and adjusting the position of the far object. On the outside of the panel suitable buttons and switches are provided for these controls and a dial or time interval scale with hands that can be set to give the values of exposure desired. This form of the instrument has been designed especially to give compactness of construction and the maximum convenience of operation.

Either of the above forms of the instrument makes possible the following determinations: (a) The use of a set of very sensitive tests which take into account as no other tests do both the motor and the sensory functions of the eyes in just the proportion that they occur in the act of seeing objects in different directions and at different distances. (b) The testing of the dynamic speed of vision with either the oculomotor or the accommodative feature emphasized. In the dynamic test for speed of vision the eyes are required to shift their regard from one object to another or to a series of objects and to discriminate them in turn during the time or times of exposure. These conditions test not only the speed of reaction of the sensorium but also the oculomotor facility and proficiency. And (c) the measurement of the time required to change from near to far and from far to near in combination or separately.

The instrument and test have the following practical uses: (a) A means of detecting abnormalities and depressions in the oculomotor functions in the work of the clinic; (b) a test for vocational fitness in all cases in which dynamic speed of vision is an important requirement; (c) a limiting test for age; (d) a means of measuring ocular and oculomotor fatigue and recovery and of testing individual susceptibility to ocular fatigue and the capacity to recover. Because of the profound effect of fatigue and other disturbances of bodily and mental efficiency on such highly organized and delicate muscular coordinations as are required in the speedy use of the eyes, the test may be used also as a very sensitive means of detecting bodily and mental fatigue and other disturbances in physical and mental proficiency which occur so frequently in the normal course of living. It may be used also for detecting and studying the effect of altitude, temperature and other variations in the physical conditions to which the aviator is subjected. And (e) a means of training the eyes to greater oculomotor and accommodative efficiency.

SUMMARY

With the growing conviction that the pilot is an important factor in the increasing number of airplane crashes, it seems that more attention should be paid to fitness in the selection of pilots and to making sure that they are fit for service at all times when they are called upon to render service. It is strange indeed that so much care is taken to see that the plane is in perfect condition before a flight is undertaken and so little attention is given to the condition of the pilot. While it is true that a human being can not be treated as a machine, we do know that he is subject to many disturbances from day to day that render him unfit for those services which require a supernormal fitness and proficiency and involve a responsibility for human life and safety. These disturbances can be shown by test.

In the paper a very sensitive test for these disturb-

ances in fitness is proposed and a convenient instrument for giving the test is briefly described. The test falls well within the technical capabilities of the average flight surgeon and should not require more than ten minutes to perform. It is recommended that the test should be given both immediately before and immediately after each flight. Reasons for this are: (1) The test before the flight can be used to prevent the aviator from going into the air when he is clearly and dangerously unfit for service. It is neither fair nor good public policy that a knowledge of his fitness should depend upon his own report. The responsibility for making such report should be taken out of his hands and consigned to a competent examiner. (2) The test at the end of the flight would indicate how well the aviator has stood the strain of his service. It would give valuable information as to his susceptibility to fatigue and make it possible to assign him to the length and kind of service he is capable of performing. It would also give a great deal of valuable general information as to the number of hours in the air and the amount of strain which aviators, taken collectively, can reasonably be expected to stand. (3) From the results of the tests, graphs or curves can be plotted which will give a splendid picture of the aviator's fitness, his endurance, his susceptibility to fatigue, the consistency of his service, etc. From these graphs it can also be readily seen when the aviator is becoming incapacitated for service through age or some other cause.

C. E. FERREE
G. RAND

SPECIAL ARTICLES

VISUAL PURPLE AND ROD VISION[1]

So much evidence has accumulated to show an approximate agreement between the absorption spectrum of visual purple and the spectral sensitivity at low intensity (rod vision) in the mammal that there can be little doubt that this substance is the light absorber for the process. Hecht and Williams[2] (1922) compared their data for the human retina with the average values for mammalian visual purple obtained by Köttgen and Abelsdorff,[3] and pointed out that the spectral sensitivity curve was uniformly displaced about 7 mμ toward the red from the absorption spectrum. This they accounted for on the basis of Kundt's rule, which states that the greater the refractive index of the solvent, the farther is the absorption spectrum shifted toward the red. They assumed that the solvent medium in the rods is of a higher refractive index than the aqueous solution in which the absorption spectrum of the visual purple was measured. Actually Kundt's rule has so many exceptions that it can hardly be regarded as a rule at all, so that this explanation is of little value, and it is the purpose of the present communication to show that if the data are properly expressed they can be made to agree within the limits of experimental variation so that there is no need of assuming a displacement toward the red nor invoking the questionable rule of Kundt.

It must be recalled in making such a comparison that while absorption spectra are always measured in terms of energies, the receptor actually responds to number of quanta. The latter must be true if the receptor response is based on some sort of photochemical process, which seems certain. Thus it is necessary to convert absorbed energies into number of quanta before comparing them with the relative stimulating energies. There are numerous factors which may prevent an agreement between the absorption spectrum and the receptor sensitivity, but no correspondence is to be expected except on the above basis.

The conversion from energies into relative number of quanta is easily made, since the size of the quantum is related to the wave-length in the following manner: $\varepsilon = hc/\lambda$, where ε is the quantum, h Planck's constant, c the velocity of light, and λ the wave-length. Since both h and c are constants, the quantum must be inversely proportional to λ. Thus the number of quanta in equal intensities of light of different wave-length is directly proportional to the wave-length, so that absorbed energies may be converted into relative number of quanta by merely multiplying by the wavelength. Since the wave-length range is not great in the present case, the correction can not be of great magnitude; in fact, Hecht[4] dismisses it in a recent review (1937) by the following statement: "Strictly, the assumption should be that a constant number of quanta is required, but because of the small range of wavelengths the difference between the two is negligible." However, the accompanying curves will show that the correction is of just sufficient magnitude to take care completely of the discrepancy pointed out by Hecht and Williams (1922) and still explained by Hecht on the basis of Kundt's rule in 1937.

In Fig. 1 are plotted the data of Hecht and Williams for the sensitivity of the dark-adapted human eye at very low light intensity, together with the measurements of mammalian visual purple by Köttgen and

[1] The Division of Physiology, University of California Medical School, Berkeley, Calif.

[2] S. Hecht and R. E. Williams, *Jour. Gen. Physiol.*, 5: 1, 1922.

[3] E. Köttgen and G. Abelsdorff, *Ztschr. f. Psych. u. Physiol. d. Sinnesorgane*, 12: 161, 1896.

[4] S. Hecht, *Physiol. Rev.*, 17: 239, 1937.